



# System Considerations

<b>8.1</b>	Traffic Signals at Roundabouts	213
8.1.1	Metered entrance	214
8.1.2	Nearby vehicular and pedestrian signals	214
8.1.3	Full signalization of the circulatory roadway	215
<b>8.2</b>	At-Grade Rail Crossings	215
<b>8.3</b>	Closely Spaced Roundabouts	217
<b>8.4</b>	Roundabout Interchanges	219
8.4.1	Two-bridge roundabout interchange	219
8.4.2	One-bridge roundabout interchange	220
8.4.3	Analysis of roundabout interchanges	222
8.4.4	Geometric design parameters	223
<b>8.5</b>	Roundabouts in an Arterial Network	223
8.5.1	Platooned arrivals on roundabout approaches	224
8.5.2	Roundabout departure pattern	224
8.5.3	Wide nodes and narrow roads	225
<b>8.6</b>	Microscopic Simulation	227
8.6.1	How to use simulation	227
8.6.2	Examples of simulation models	228
<b>8.7</b>	References	229

<b>Exhibit 8-1.</b>	Rail crossing treatments at roundabouts.	216
<b>Exhibit 8-2.</b>	Methods for accommodating a rail crossing adjacent to a roundabout.	217
<b>Exhibit 8-3.</b>	Example of closely spaced offset T-intersections with roundabouts.	218
<b>Exhibit 8-4.</b>	Through bypass lanes at staggered T-intersections.	218
<b>Exhibit 8-5.</b>	Two-bridge roundabout interchange.	219
<b>Exhibit 8-6.</b>	Examples of two-bridge roundabout interchanges.	220
<b>Exhibit 8-7.</b>	Examples of one-bridge roundabout interchanges with circular central islands.	221
<b>Exhibit 8-8.</b>	One-bridge roundabout interchange with raindrop-shaped central islands.	222
<b>Exhibit 8-9.</b>	Roundabouts in an arterial network.	223
<b>Exhibit 8-10.</b>	Wide nodes and narrow roads.	226
<b>Exhibit 8-11.</b>	Summary of simulation models for roundabout analysis.	228

## Chapter 8 System Considerations

Roundabouts have been considered as isolated intersections in most other international roundabout guides and publications. However, roundabouts may need to fit into a network of intersections, with the traffic control functions of a roundabout supporting the function of nearby intersections and vice versa. The purpose of this chapter is to provide some guidance on potentially difficult, but not uncommon, circumstances or constraints.

Many countries whose initial design and driver experience was with isolated roundabouts have since extended their application to transportation system design and operation. This chapter addresses the appropriate use of roundabouts in a roadway network context and the benefits obtained. Since the design of each roundabout should generally follow the principles of isolated roundabout design, the discussion is at a conceptual and operational level and generally complements the planning of isolated roundabouts discussed in Chapter 3. In many cases, site-specific issues will determine the appropriate roundabout design elements.

To establish some fundamental understanding for subsequent discussion, three design issues at an isolated roundabout are presented. First, this chapter will describe the requirements and effects of signal control of one or more legs of a roundabout, as well as the entire roundabout. It is noted that fully signalized roundabouts are not desirable. Next, modified designs that incorporate at-grade rail crossings are discussed. It is noted that intersections with rail lines passing through them or near them are not desirable. However, these situations do occur and would then need to be analyzed.

Building upon this understanding, the next sections address design and performance of two closely spaced roundabouts and the specific application to roundabout interchanges. This is followed by issues pertaining to the use of roundabouts on an arterial or network that may include or replace coordinated signalized intersections. Finally, the role of microscopic simulation models in assisting with analysis of these system effects is reviewed.

**This chapter considers roundabouts as they relate to other elements of the transportation system, including other intersections.**

### 8.1 Traffic Signals at Roundabouts

Although yield control of entries is the default at roundabouts, when necessary, traffic circles and roundabouts have been signalized by metering one or more entries, or signalizing the circulatory roadway at each entry. Roundabouts should never be planned for metering or signalization. However, unexpected demand may dictate the need after installation. Each of these will be discussed in turn. In the first case, entrance metering can be implemented at the entrance or some distance upstream.

**Roundabouts should not be planned for metering or signalization unless unexpected demand dictates this need after installation.**

### **8.1.1 Metered entrance**

Roundabouts operate effectively only when there are sufficient longer and acceptable gaps between vehicles in the circulatory lanes. If there is a heavy movement of circulating drivers, then entering drivers at the next downstream entry may not be able to enter. This situation occurs most commonly during the peak periods, and the performance of the roundabout can be greatly improved with entrance metering.

The concept of entrance metering at roundabouts is similar to ramp metering on freeways. A convenient sign is a changeable one that reads "Stop on red signal" and shows the usual yield sign for a roundabout otherwise. The sign would also include a yellow and red signal above the sign. The operation of the sign would be to show drivers the roundabout sign, display the yellow light and the sign "Stop on red signal," and finally display the red light and the same text sign. This would cause entering vehicles to stop and allow the vehicles at the downstream entrance to proceed. A queue length detector on the downstream entrance may be used to indicate to the signal controller when the metering should be activated and deactivated. Once on the circulatory roadway, vehicles are not stopped from leaving the roundabout.

### **8.1.2 Nearby vehicular and pedestrian signals**

**Nearby intersections or pedestrian crossing signals can also meter traffic, but not as effectively as direct entrance metering.**

Another method of metering is the use, with appropriate timing, of a nearby upstream signalized intersection or a signalized pedestrian crossing on the subject approach road. Unlike pure entry metering, such controls may stop vehicles from entering and leaving the roundabout, so expected queue lengths on the roundabout exits between the metering signal and the circulatory roadway should be compared with the proposed queuing space.

Because of additional objectives and constraints, metering by upstream signals is generally not as effective as direct entrance metering. However, a signalized pedestrian crossing may be desirable on its own merits. More than one entrance can be metered, and the analyst needs to identify operational states and evaluate each one separately to provide a weighted aggregate performance measure.

When disabled pedestrians and/or school children are present at a high-volume site, a pedestrian-actuated traffic signal could be placed 20 to 50 m (65 to 165 ft) from the yield line. This longer distance than at an unsignalized crossing may be required because the vehicle queues downstream of the roundabout exit will be longer. The trade-offs for any increased distance requirement are increased walking distances and higher exiting vehicle speeds. An analysis of signal timing will be needed to minimize queuing of vehicles into the roundabouts.

### **8.1.3 Full signalization of the circulatory roadway**

Full signalization that includes control of circulating traffic at junctions with major entrances is possible at large-diameter multilane traffic circles or rotaries that have adequate storage space on the circulatory roadway. The double-lane roundabout dimensions resulting from the design criteria recommended in this guide may preclude such possibilities. As stated previously, full signalization should in any case only be considered as a retrofit alternative resulting from unanticipated traffic demands. Other feasible alternatives should also be considered, such as flaring critical approaches, along with the associated widening of the circulatory roadway; converting a large-diameter rotary to a more compact modern roundabout form; or converting to a conventional signalized intersection. This guide recommends that signalizing roundabouts to improve capacity be considered only when it is the most cost-effective solution.

**Full signalization of the circulatory roadway requires careful coordination and vehicle progression.**

Traffic signals at fully signalized rotaries should be timed carefully to prevent queuing on the circulatory roadway by ensuring adequate traffic progression of circulating traffic and especially critical movements. Introducing continuous or part-time signals on the circulatory roadway requires careful design of geometry, signs, lane markings, and signal timing settings, and literature on this specific topic should be consulted (1, 2).

## **8.2 At-Grade Rail Crossings**

Locating any intersection near an at-grade railroad crossing is generally discouraged. However, roundabouts are sometimes used near railroad-highway at-grade crossings. Rail transit, including stations, have successfully been incorporated into the medians of approach roadways to a roundabout, with the tracks passing through the central island. In such situations, the roundabout either operates partially during train passage, or is completely closed to allow the guided vehicles or trains to pass through. The treatment of at-grade rail crossings should follow primarily the recommendations of the *Manual on Uniform Traffic Control Devices* (MUTCD) (3). Another relevant reference is the *FHWA Railroad-Highway Grade Crossing Handbook* (4).

There are essentially two ways in which rails can interact with a roundabout, as shown in Exhibit 8-1:

- Through the center; or
- Across one leg in close proximity to the roundabout.

In either case, traffic must not be forced to stop on the tracks. A new intersection should not be designed with railroad tracks passing through the center of it. However, on occasions, the rail line passes through an existing intersection area. The traffic engineer might be faced with a decision whether to change the intersection type to a roundabout or to grade-separate the crossing.

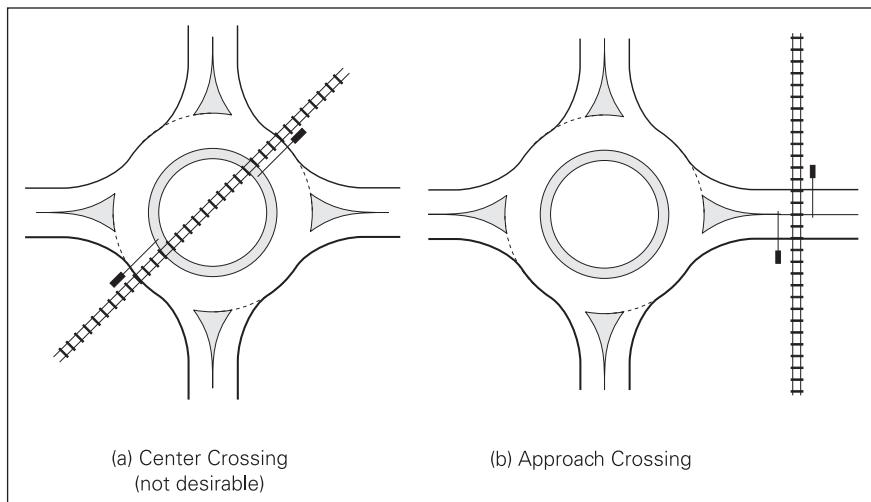
A gated rail crossing through the center of a roundabout can be accommodated in two ways. The first method is to prevent all vehicular traffic from entering the roundabout. The second method is to prevent traffic from crossing the tracks while still allowing some movements to occur. This latter method will have lower delays and queues, but it may be more confusing and less safe.

A gated rail crossing adjacent to a roundabout can be accommodated in two ways, as shown in Exhibit 8-2:

**Closing only the leg with the rail crossing may work if queues are not anticipated to back into the circulatory roadway.**

- *Method A: Closure only at rail crossing.* This method prohibits vehicles from crossing the rails but still allows vehicles to enter and leave the circulatory roadway. This method allows for many of the movements through the roundabout to continue to run free, if a queue does not build to the point of impeding circulation within the roundabout. A queuing analysis should be performed using the expected volume crossing the rails and the expected duration of rail crossing to determine the likelihood that this blockage will occur. In general, this method works better than Method B if there is sufficient separation between the roundabout and the rail crossing. If blockage is anticipated, the designer should choose Method B.
- *Method B: Closure at rail crossing and at most entries to the roundabout.* This method closes all entries to the roundabout except for the entry nearest the rail crossing. This allows any vehicles in the roundabout to clear prior to the arrival of the train. In addition, a gate needs to be provided on the approach to the rail crossing exiting the roundabout to protect against possible U-turns in the roundabout. This causes increased queuing on all approaches but is generally safer than Method A when there is insufficient storage capacity between the roundabout and rail crossing.

Exhibit 8-1. Rail crossing treatments at roundabouts.



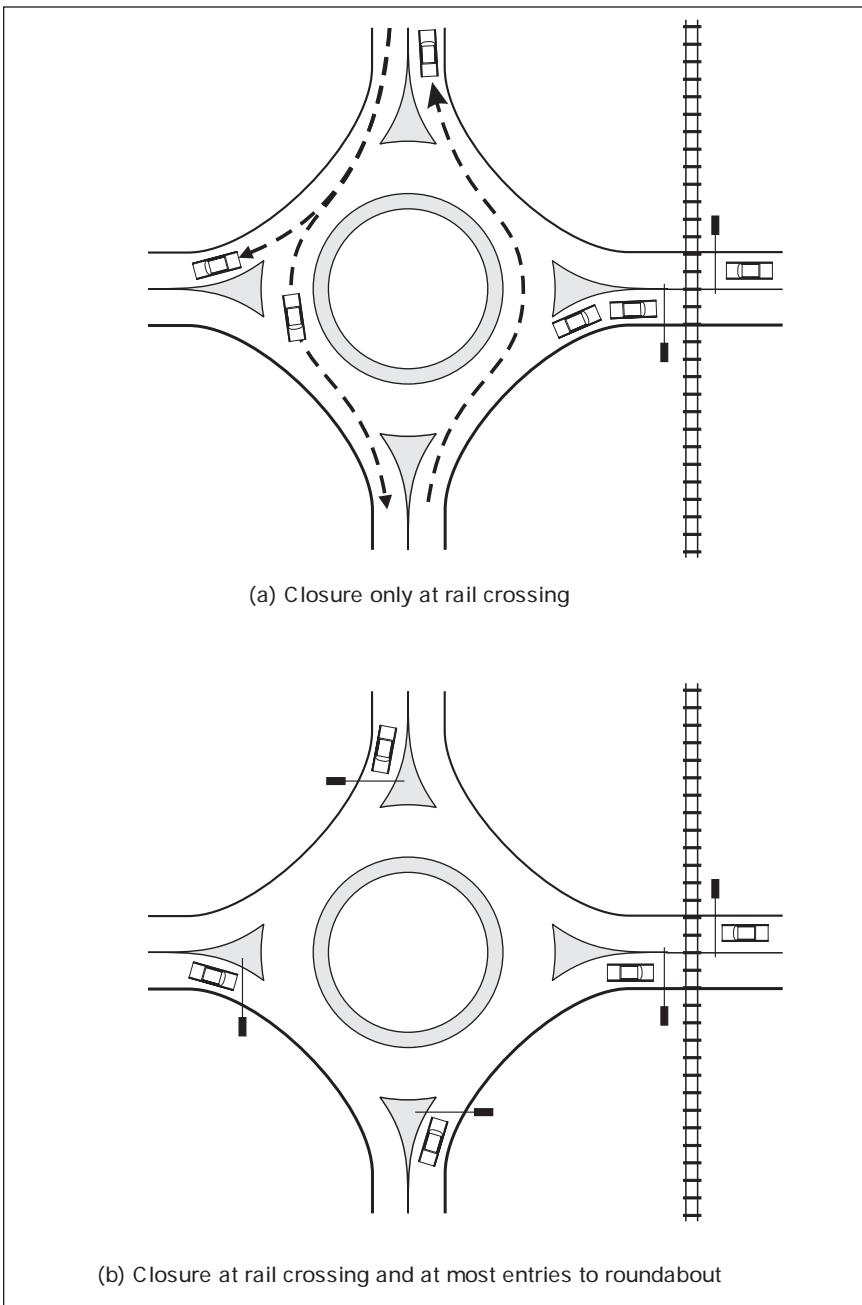


Exhibit 8-2. Methods for accommodating a rail crossing adjacent to a roundabout.

### 8.3 Closely Spaced Roundabouts

It is sometimes desirable to consider the operation of two or more roundabouts in close proximity to each other. In these cases, the expected queue lengths at each roundabout become important. Exhibit 8-3 presents an example of closely spaced T-intersections. The designer should compute the 95th-percentile queues for each approach to check that sufficient queuing space is provided for vehicles between the roundabouts. If there is insufficient space, then drivers will occasionally queue into the upstream roundabout and may cause it to lock.

Exhibit 8-3. Example of closely spaced offset T-intersection with roundabouts.



France (5)

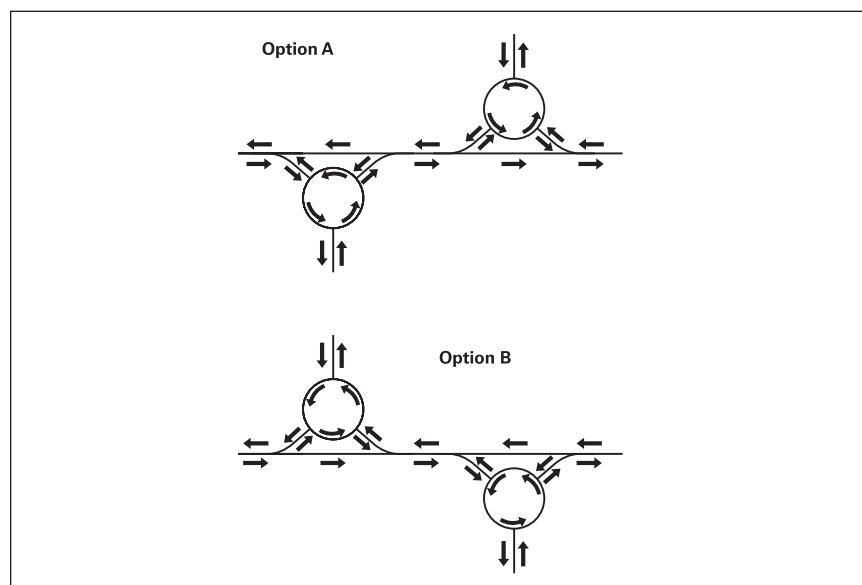
**Closely spaced roundabouts may have a traffic calming effect on the major road.**

Closely spaced roundabouts may improve safety by "calming" the traffic on the major road. Drivers may be reluctant to accelerate to the expected speed on the arterial if they are also required to slow again for the next close roundabout. This may benefit nearby residents.

When roundabouts are used at offset T-intersections, there is an opportunity to bypass one through lane direction on the major road at each roundabout. Exhibit 8-4 presents sketches of through bypass lanes for the two basic types of offset T-intersection configurations. In both cases, through traffic in each direction needs to negotiate only one roundabout, and capacity is therefore typically improved. The weaving section should be analyzed both for capacity and for safety through an evaluation of the relative speeds of the weaving vehicles.

Exhibit 8-4. Through bypass lanes at staggered T-intersections.

**Option A (roundabout precedes bypass) is preferred.**



Of the two arrangements shown in Exhibit 8-4, Option A (roundabout precedes bypass) is preferred. The roundabout offers a visual cue to drivers to slow in Arrangement A and encourages slower (and therefore safer) driving through the two roundabouts. If Option B (bypass precedes roundabout) is used, the merges and diverges could occur at higher speeds. It may be appropriate in this case to omit the bypass lane and pass all through traffic through both roundabouts. Another advantage of Option A is that there would be less queuing of traffic on the road space between the roundabouts.

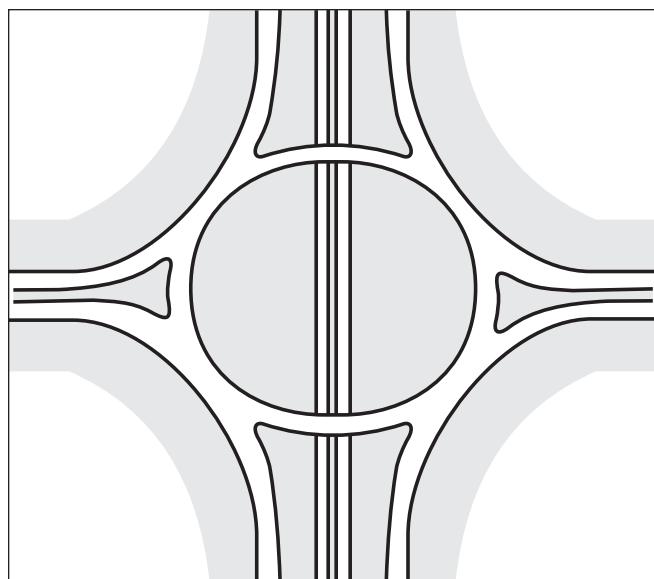
Note that when conventional T-intersections are used, Option A is less preferable than Option B due to the need to provide interior storage space for left turns in Option A. Therefore, roundabouts may be a satisfactory solution for cases like Option A.

## 8.4 Roundabout Interchanges

Freeway ramp junctions with arterial roads are potential candidates for roundabout intersection treatment. This is especially so if the subject interchange typically has a high proportion of left-turn flows from the off-ramps and to the on-ramps during certain peak periods, combined with limited queue storage space on the bridge crossing, off-ramps, or arterial approaches. In such circumstances, roundabouts operating within their capacity are particularly amenable to solving these problems when compared with other forms of intersection control.

### 8.4.1 Two-bridge roundabout interchange

There are two basic types of roundabout interchanges. The first is a large diameter roundabout centered over or under a freeway. The ramps connect directly into the roundabout, as do the legs from the crossroad. This is shown in Exhibit 8-5.



Source: Based on (6)

Exhibit 8-5. Two-bridge roundabout interchange.

The freeway may go either over or under the circulatory roadway.

This type of interchange requires two bridges. If the roundabout is above the freeway as shown in Exhibit 8-5, then the bridges may be curved. Alternatively, if the freeway goes over the roundabout then up to four bridges may be required. The number of bridges will depend on the optimum span of the type of structure compared with the inscribed diameter of the roundabout island and on whether the one bridge is used for both freeway directions or whether there is one bridge for each direction. The road cross-section will also influence the design decision. Exhibit 8-6 shows an example from the United Kingdom. The designer should decide if the expected speeds of vehicles at larger roundabouts are acceptable.

Exhibit 8-6. Examples of two-bridge roundabout interchanges.



A50/Heron Cross, United Kingdom (mirrored to show right-hand-side driving)

#### 8.4.2 One-bridge roundabout interchange

The second basic type uses a roundabout at each side of the freeway and is a specific application of closely spaced roundabouts discussed in the previous section. A bridge is used for the crossroad over the freeway or for a freeway to cross over the minor road. Again, two bridges may be used when the freeway crosses over the minor road.

**One-bridge roundabout interchanges have been successfully used to defer the need for bridge widening.**

This interchange form has been used successfully in some cases to defer the need to widen bridges. Unlike signalized ramps that may require exclusive left-turn lanes across the bridge and extra queue storage, this type of roundabout interchange exhibits very little queuing between the intersections since these movements are almost unopposed. Therefore, the approach lanes across the bridge can be minimized.

The actual roundabouts can have two different shapes or configurations. The first configuration is a conventional one with circular central islands. This type of configuration is recommended when it is desirable to allow U-turns at each roundabout or to provide access to legs other than the cross street and ramps. Examples from the United Kingdom and France are shown in Exhibit 8-7.



Exhibit 8-7. Examples of one-bridge roundabout interchanges with circular central islands.



Exhibit 8-7 (continued). Examples of one-bridge roundabout interchanges with circular central islands.

France

**Raindrop central islands make wrong-way movements more difficult, but require navigating two roundabouts to make a U-turn.**

The second configuration uses raindrop-shaped central islands that preclude some turns at the roundabout. This configuration is best used when ramps (and not frontage roads) intersect at the roundabout. A raindrop central island can be considered to be a circular shape blocked at one end. In this configuration, a driver wanting to make a U-turn has to drive around both raindrop-shaped central islands. This configuration has an additional advantage in that it makes wrong-way turns into the off-ramps more difficult. On the other hand, drivers do not have to yield when approaching from the connecting roadway between the two roundabouts. If the roundabout is designed poorly, drivers may be traveling faster than they should to negotiate the next roundabout safely. The designer should analyze relative speeds to evaluate this alternative. On balance, if the length of the connecting road is short, this design may offer safety advantages. Exhibit 8-8 provides an example of this type of interchange configuration.

Exhibit 8-8. One-bridge roundabout interchange with raindrop-shaped central islands.



Interstate 70/Avon Road, Avon, CO

#### 8.4.3 Analysis of roundabout interchanges

The traffic performance evaluation of the roundabout interchange is the same as for a single conventional roundabout. The maximum entry capacity is dependent on the circulatory flow and the geometry of the roundabouts. The evaluation process is included in Chapter 4.

**Roundabouts produce more random headways on ramps than signalized intersections, resulting in smoother merging behavior on the freeway.**

The benefits and costs associated with this type of interchange also follow those for a single roundabout. A potential benefit of roundabout interchanges is that the queue length on the off-ramps may be less than at a signalized intersection. In almost all cases, if the roundabout would operate below capacity, the performance of the on-ramp is likely to be better than if the interchange is signalized. The headway between vehicles leaving the roundabout along the on-ramp is more random than when signalized intersections are used. This more random ramp traffic allows for smoother merging behavior on the freeway and a slightly higher performance at the freeway merge area compared with platooned ramp traffic from a signalized intersection.

The traffic at any entry is the same for both configurations. The entry capacity is the same and the circulating flow is the same for the large single roundabout (Exhibit 8-6) and for the second configuration of the two teardrop roundabout system (Exhibit 8-8). Note that the raindrop form may be considered and analyzed as a single large roundabout as in the circular roundabout interchange, but with a “pinched” waistline across or under one bridge rather than two. The relative performance of these systems will only be affected by the geometry of the roundabouts and islands. The system with the two circular roundabouts will have a slightly different performance depending upon the number of U-turns.

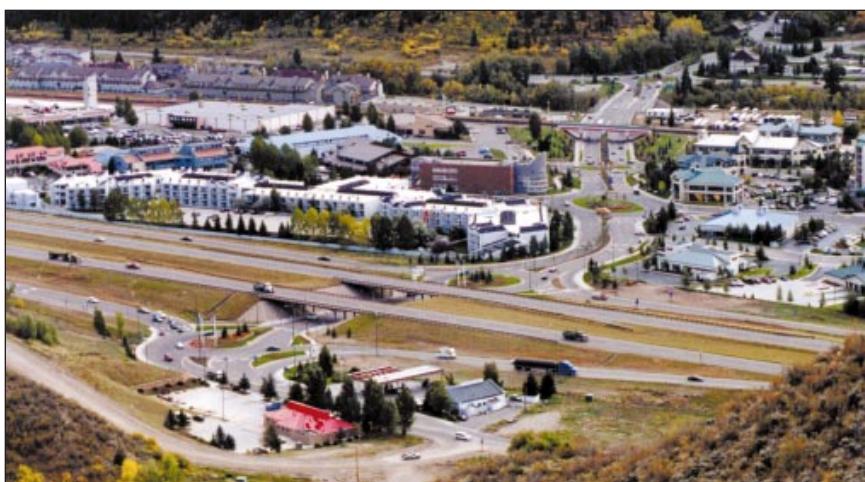
#### 8.4.4 Geometric design parameters

The design parameters are not restrained by any requirement here. They are only constrained by the physical space available to the designer and the configuration selected. The raindrop form can be useful if grades are a design issue since they remove a potential cross-slope constraint on the missing circulatory road segments.

If there are more roads intersecting with the interchange than the single cross road, then two independent circular roundabouts are likely to be the best solution.

### 8.5 Roundabouts in an Arterial Network

In order to understand how roundabouts operate within a roadway system, it is important to understand their fundamental arrival and departure characteristics and how they may interact with other intersections. Exhibit 8-9 gives an example of a series of roundabouts along an arterial street.



Avon Road, Avon, CO

Exhibit 8-9. Roundabouts in an arterial network.

**The Avon Road network consists of five roundabouts (all pictured)—two at the interchange ramp terminals and three along the arterial south of the freeway.**

**Signalized intersections close to roundabouts produce gaps in traffic that can be used by minor street traffic to enter the major street.**

### 8.5.1 Platooned arrivals on roundabout approaches

The performance of a roundabout is affected by its proximity to signalized intersections. If a signalized intersection is very close to the roundabout, it causes vehicles to enter the roundabout in closely spaced platoons; more importantly, it results in regular periods when no vehicles enter. These latter periods provide an excellent opportunity for traffic on the next downstream entry to enter. Since the critical gap is larger than the follow-up time, a roundabout becomes more efficient when the vehicles are handled as packets of vehicles rather than as isolated vehicles.

When the signalized intersection is some distance from the roundabout, then the vehicles' arrival patterns have fewer closely spaced platoons. Platoons tend to disperse as they move down the road. The performance of a roundabout will be reduced under these circumstances when compared with a close upstream signal. If arrival speeds are moderate, then few longer gaps allow more drivers to enter a roundabout than a larger number of shorter gaps. If arrival speeds are low, then there are more opportunities for priority-sharing (where entering and circulating vehicles alternate) and priority-reversals (where the circulating vehicles tend to yield to entering vehicles) between entering and circulating traffic streams, and the influence of platoon dispersal is not as marked.

### 8.5.2 Roundabout departure pattern

Traffic leaving a roundabout tends to be more random than if another type of intersection control were used. A roundabout may therefore affect the performance of other unsignalized intersections or driveways more than if the intersection was signalized. However, as this traffic travels further along the road downstream of the roundabout, the faster vehicles catch up to the slower vehicles and the proportion of platooning increases.

In the case of a well-defined platoon from an upstream signalized intersection arriving at a downstream unsignalized intersection just after a well-defined platoon arrives from the other direction, it may be difficult for the minor street drivers at this unsignalized intersection to enter the link. If, on the other hand, one of these signalized intersections were to be replaced by a roundabout, then the effect of the random traffic from the roundabout might be relatively advantageous. Under these conditions, more dispersed platoons (or random) traffic could assist drivers entering along the link at the unsignalized intersection.

**Even one circulating vehicle in a roundabout will result in a platoon breaking down.**

If a roundabout is used in a network of coordinated signalized intersections, then it may be difficult to maintain the closely packed platoons required. If a tightly packed platoon approached a roundabout, it could proceed through the roundabout as long as there was no circulating traffic or traffic upstream from the left. Only one circulating vehicle would result in the platoon breaking down. Hence, the use of roundabouts in a coordinated signalized network needs to be evaluated carefully. One possibility for operating roundabouts within a signal network is to signalize the major approaches of the roundabout and coordinate them with adjacent upstream and downstream signalized intersections.

Another circumstance in which a roundabout may be advantageous is as an alternative to signal control at a critical signalized intersection within a coordinated network. Such intersections are the bottlenecks and usually determine the required cycle length, or are placed at a signal system boundary to operate in isolated actuated mode to minimize their effect on the rest of the surrounding system. If a roundabout can be designed to operate within its capacity, it may allow a lowering of the system cycle length with resultant benefits to delays and queues at other intersections.

Because roundabouts accommodate U-turns more easily than do signals, they may also be useful as an access management tool. Left-turn exits from driveways onto an arterial which may currently experience long delays and require two-stage left-turn movements could be replaced with a simpler right turn, followed by a U-turn at the next roundabout.

**Roundabouts as an access management tool.**

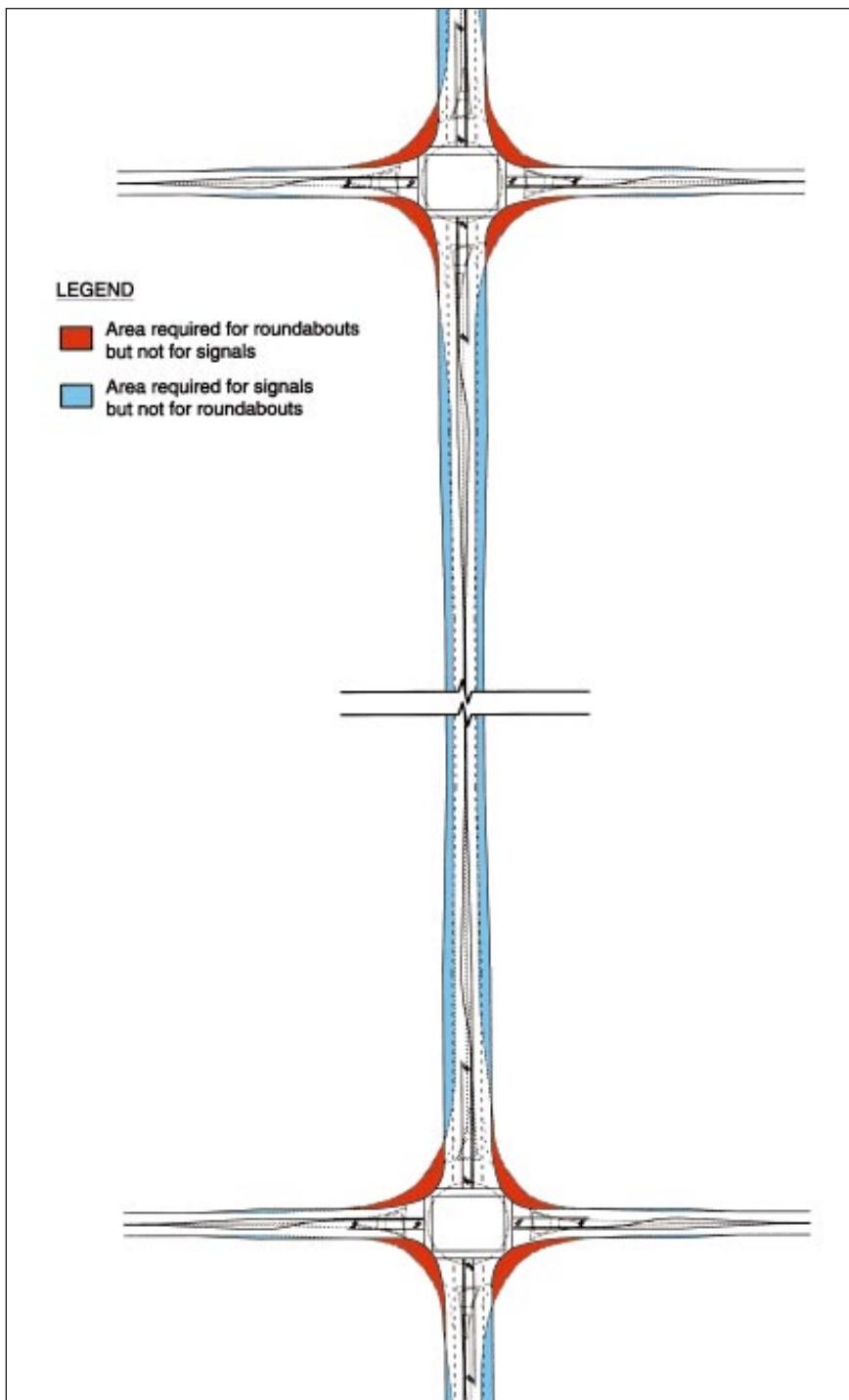
### **8.5.3 Wide nodes and narrow roads**

The ultimate manifestation of roundabouts in a system context is to use them in lieu of signalized intersections. Some European cities such as Nantes, France, and some Australian cities have implemented such a policy. It is generally recognized that intersections (or nodes), not road segments (or links), are typically the bottlenecks in urban roadway networks. A focus on maximizing intersection capacity rather than widening streets may therefore be appropriate. Efficient, signalized intersections, however, usually require that exclusive turn lanes be provided, with sufficient storage to avoid queue spillback into through lanes and adjacent intersections. In contrast, roundabouts may require more right-of-way at the nodes, but this may be offset by not requiring as many basic lanes on the approaches, relative to signalized arterials. This concept is demonstrated in Exhibit 8-10.

**Roundabouts may require more right-of-way at intersections, but may also allow fewer lanes (and less right-of-way) between intersections.**

Analysis tools, such as those provided in Chapter 4, should be used to evaluate the arterial or network. These may be supplemented by appropriate use of microscopic simulation models as discussed next. Supplemental techniques to increase the capacity of critical approaches may be considered if necessary, such as bypass lanes, flaring of approaches and tapering of exits, and signalization of some roundabout approaches.

Exhibit 8-10. Wide nodes and narrow roads.



## 8.6 Microscopic Simulation

Microscopic simulation of traffic has become a valuable aid in assessing the system performance of traffic flows on networks, as recognized by the *Highway Capacity Manual 2000* (7). Analysis of many of the treatments discussed in this chapter may benefit from the use of appropriate simulation models used in conjunction with analytic models of isolated roundabouts discussed in Chapter 4. These effects include more realistic modeling of arrival and departure profiles, time-varying traffic patterns, measurement of delay, spatial extent and interaction of queues, fuel consumption, emissions, and noise. However, the user must carefully select the appropriate models and calibrate the model for a particular use, either against field data, or other validated analytic models. It would also be advisable to check with others to see if there have been any problems associated with the use of the model.

### 8.6.1 How to use simulation

Microscopic simulation models are numerous and new ones are being developed, while existing models are upgraded frequently. Each model may have particular strengths and weaknesses. Therefore, when selecting a model, analysts should consider the following:

- Should a simulation model be used, or is an isolated analytic roundabout model sufficient?
- What are the model input requirements, are they sufficient, and how can they be provided or estimated?
- What outputs does the model provide in animated, graphical, or tabular form?
- What special features of the model are pertinent to the problem being addressed?
- Does the user manual for the simulation model specifically address modeling a roundabout?
- How sensitive is the model to various geometric parameters?
- Is there literature on the validation of this model for evaluating roundabouts?
- Is there sufficient information available on the microscopic processes being used by the model such as car following, gap acceptance, lane changing, or steering? (The availability of animation can assist in exposing model logic.)
- Are relevant past project examples available?

When a simulation model is used, the analyst is advised to use the results to make relative comparisons of the differences between results from changing conditions, and not to conclude that the absolute values found from the model are equivalent to field results. It is also advisable to perform a sensitivity analysis by changing selected parameters over a range and comparing the results. If a particular parameter is found

**Simulation results are best used for relative comparisons, rather than relying on absolute values produced by the model.**

to affect the outcomes significantly, then more attention should be paid to accurate representation and calibration of this parameter. Finally, the analyst should check differences in results from using different random number seeds. If the differences are large, then the simulation time should be increased substantially.

### 8.6.2 Examples of simulation models

Five commercially available microscopic simulation models are CORSIM, Integration, Simtraffic, Paramics, and VISSIM. The first three are North American models; Paramics is from Scotland, and VISSIM is from Germany. The following sections present a brief overview of each model. Since software packages (and simulation models in particular) are in constant development, the user is encouraged to consult the most current information available on each model.

Exhibit 8-11. Summary of simulation models for roundabout analysis.

Name	Scope	Notes (1999 versions)
CORSIM	Urban streets, freeways	FHWA has been investigating modifications that may be required for CORSIM to adequately model controls such as stop and yield control at roundabouts through gap acceptance logic. In this research, roundabouts have been coded as a circle of four yield-controlled T-intersections. The effect of upstream signals on each approach and their relative offsets has also been reported (8).
Integration	Urban streets, freeways	Integration has documented gap acceptance logic for permitted movements at signal-, yield-, and stop-controlled intersections. As with CORSIM, Integration requires coding a roundabout simply as a series of short links and nodes with yield control on the entrances.
Simtraffic	Urban streets	Simtraffic is a simulation model closely tied to the signal timing software package Synchro. Simtraffic has the capability to model unsignalized intersections and thus may be suitable for modeling roundabouts. However, no publications to date have demonstrated the accuracy of Simtraffic in modeling roundabout operations.
Paramics	Urban streets, freeways	Paramics has been used in the United Kingdom and internationally for a wide range of simulation projects. It has been specifically compared with ARCADY in evaluating roundabouts (9). The model has a coding feature to automatically code a roundabout intersection at a generic node, which may then be edited. The model has been used in the United Kingdom for a number of actual roundabout evaluations. The model specifically employs a steering logic on the circulatory roadway to track a vehicle from an entry vector to a target exit vector (10).
VISSIM	Urban streets, transit networks	VISSIM is widely used in Germany for modeling urban road and transit networks, including roundabouts. Roundabout examples are provided with the software, including explicit modeling of transit and pedestrians. Modeling a roundabout requires detailed coding of link connectors, control, and gap acceptance parameters (11).

## 8.7 References

1. Brown, M. *TRL State of the Art Review—The Design of Roundabouts*. London: HMSO, 1995.
2. Hallworth, M.S. "Signalling Roundabouts." In *Traffic Engineering + Control*, Vol. 33, No. 6, June 1992.
3. Federal Highway Administration (FHWA). *Manual on Uniform Traffic Control Devices*. Washington, D.C.: FHWA, 1988.
4. Federal Highway Administration. *Railroad-Highway Grade Crossing Handbook*, 2nd edition. Report number FHWA-TS-86-215, September 1986.
5. Centre D'Etudes sur les Réseaux, les Transports, l'Urbanisme, et les Constructions Publiques (CERTU) (Center for Studies on Transportation Networks, Urban Planning, and Public Works). *Carrefours Urbains (Urban Intersections)* Guide. Lyon, France: CERTU, January 1999.
6. Department of Transport (United Kingdom). *Geometric Design of Roundabouts*. TD 16/93. September 1993.
7. Transportation Research Board. *Highway Capacity Manual*. Special Report 209. Washington, D.C.: Transportation Research Board, National Research Council, July 1999 (draft).
8. Courage, K.G. "Roundabout Modeling in CORSIM." Presented at the Third International Symposium on Intersections without Traffic Signals, Portland, Oregon, U.S.A., 1997.
9. Paramics, Ltd. "Comparison of Arcady and Paramics for Roundabout Flows." Version 0.3. August 23, 1996.
10. Duncan, G. "Paramics Technical Report: Car-Following, Lane-Changing and Junction Modelling." Edinburgh, Scotland: Quadstone, Ltd., 1997.
11. Innovative Transportation Concepts, LLC. *VISSIM—User Manual*. Program Version 2.32–2.36. November 10, 1997.